## RESILIENT MASSACHUSETTS ACTION TEAM (RMAT)

# DRAFT

## CLIMATE RESILIENCE DESIGN STANDARDS & GUIDELINES

## SECTION 4: DRAFT CLIMATE RESILIENCE DESIGN GUIDELINES OVERVIEW

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# RMAT CLIMATE RESILIENCE DESIGN STANDARDS AND GUIDELINES

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# 4. DRAFT CLIMATE RESILIENCE DESIGN GUIDELINES OVERVIEW

## 4.1 OVERALL GUIDELINES OVERVIEW

The "Climate Resilience Design Standards and Guidelines" project includes developing:

- a **web-tool** for agencies that provides a preliminary climate risk screening output and climate resilience design standards for State projects with physical assets
- **guidelines with best practices** for State agencies to implement climate resilience design standards;

The draft Climate Resilience Design Guidelines (the Guidelines) are intended to follow the use of the "Climate Resilience Design Standards Tool" (the Tool) and provide general design guidance for users to consider while implementing the draft Climate Resilience Design Standards (the Standards) in projects with physical assets. The draft **Guidelines** are intended to be overarching climate resilience principles that are not specific to project/asset type or climate hazards. These Guidelines are illustrated through specific draft **best practices**, which may include case studies and/or existing published resources that exemplify the Guidelines. Draft **forms** are provided to guide users through the Guidelines' considerations and document design and decision making throughout the process, as shown in Figure 4.1.

The Guidelines will be provided as web-based content on ResilientMA.org, and will include downloadable forms and case studies, as well as links to other best practices. Only the forms will be provided as downloadable PDF documents directly through the Tool outputs.


***Figure 4.1**. Project Overview Project Overview Emphasizing the Climate Resilience Design Guidelines as part of the Climate Resilience Design Standards Tool*

The draft Guidelines are structured around three main categories that were identified based on requests for guidance documented through the overall stakeholder process, as shown in Table 4.1, below.

**Table 4.1.** Draft Guideline Categories

| Guideline Category | Guidelines |
|---|---|
| Site Suitability (SS) | 1. Reduce exposure to climate hazards<br>2. Mitigate adverse climate impacts and provide benefits<br>3. Protect, conserve, and restore critical natural resources on-site and off-site |
| Regional Coordination (RC) | 1. Assess regional context of vulnerability<br>2. Evaluate impacts beyond site-specific design<br>3. Optimize capital investment opportunities<br>4. Prioritize services and assets that serve vulnerable populations |
| Flexible Adaptation Pathways (AP) | 1. Embed future capacity and design for uncertainty<br>2. Design for incremental change<br>3. Encourage climate mitigation and other co-benefits<br>4. Prioritize nature-based solutions<br>5. Prepare for current and future operational and maintenance needs |

### *4.1.1 SITE SUITABILITY GUIDELINES & BEST PRACTICES*

The draft Site Suitability Guidelines are focused on site selection, including project geographic location, existing conditions, and asset placement. Users should assess and re-assess site selection early in the design phase to ensure that the site can serve its intended function, before, during and after climate impacts. This Guidelines section does not include adaptation strategies and is focused on the potential ability of project site to reduce exposure to climate change, mitigate adverse climate impacts and/or provide benefits, and protect, conserve, and restore critical natural resources on-site and off-site. Once users have considered the Site Suitability Guidelines and best practices, they should identify whether or not they would like to proceed with their project in its planned location.

***SS-1. Reduce exposure to climate hazards:*** The location of the project has planning and design implications and is directly linked to climate exposure rating from the Climate Risk Screening Output in the Standards Tool. If you receive a high or moderate preliminary exposure rating, you may want to consider alternative site locations early in the project planning phase. There may be assets where this is unfeasible. In that case, additional consideration should be given to how the location of the project could mitigate climate impacts (SS-2) as well as flexible adaptation strategies (AP).

- *Example Case Study*: MassDOT Fuel Depot Retrofit
- *Case Study Relevance:* Site-specific climate hazard exposure was an important driver for this project, which resulted in the relocation of a district maintenance facility that was originally planned as a retrofit to an existing Fuel Depot. Given the planned asset's high criticality and near-term exposure to coastal flooding, the project team decided to select an alternative site for the new district maintenance facility. Refer to Attachment 4.2A for additional case study details.

***SS-2. Mitigate adverse climate impacts and provide benefits:*** If alternative sites with lower exposure rating scores are unfeasible for your project, there may be opportunities to reduce climate impacts as a result of the site's location and planned improvements. For

example, placing a flood barrier at the location of the initial flood pathway versus end of the flood pathway will provide more flood protection. This holds true for opportunities to increase stormwater detention and infiltration in upgradient areas of the watershed and/or cooling centers in the middle of heat islands.

- *Example Case Study*: Draw 7 Park, Somerville, MA
- *Case Study Relevance:* Located at the mouth of the Lower Mystic River watershed, the preliminary exposure ratings for both coastal and riverine flooding are high. The planned project was to revitalize the existing recreational park on the site. Based on the preliminary sea level rise and storm surge exposure and risk rating, the project team identified that the park revitalization scope could be expanded to include flood protection and a living shoreline. Additional flood modeling prepared for regional efforts showed that the site is a major flood pathway and allows future flanking of the adjacent Amelia Earhart Dam. Refer to regional coordination (RC-2) for additional information. Refer to Attachment 4.2B for additional case study details.

***SS-3. Protect, conserve, and restore critical natural resources on-site and off-site****:* The planned improvements at the site location may have detrimental impacts to critical natural resources on-site and off-site. Site Suitability should consider impacts to natural resources and ways to protect, conserve, and restore natural resources. Owners and project teams should assess what type of natural ecosystems currently exist on the site and make sure they are included for assessment in the Climate Resilience Design Standards Tool.

- *Example Best Practice:* Land conservation as resilience – Land Trust Alliance, Conservation in a Changing Climate Webpage
- *Practice Relevance:* This comprehensive webpage provides a variety of resources, best practices, and tools that help designers, planners, and the general public better understand land trusts and their importance as a tool in planning for climate change. It takes users through a framework for learning and planning in a step-by-step manner and user-friendly format. The resources are US specific and place-based, supported by the U.S. Fish and Wildlife Service.

### *4.1.2 REGIONAL COORDINATION GUIDELINES & BEST PRACTICES*

The draft Regional Coordination Guidelines are intended to help identify how resilient design and implementation can be coordinated across regions, as well as State Agencies and jurisdictions. The goal is to identify projects that can provide the most benefit to the Commonwealth and identify opportunities for collaboration and promotion of resilience. The extent of “Regional” may range depending on the scope of the project to include coordination with:

- Local regions within a Municipality (neighborhood, school districts, utility service areas, etc.)
- Private Development/Organizations
- Multiple Municipalities
- Massachusetts Regional Planning Agencies
- Watershed Authorities
- County or Counties
- MassDOT Districts
- MEMA Regions
- State Agency Climate Change Coordinators

- Neighboring States (NH, RI, CT, VT, NY)
- Federal Agencies (USACE, FHWA, FEMA, etc.)
- Others

Users should evaluate Regional Coordination early in the design process, following Site Suitability guidelines and the Outputs of the Tool. This Guidelines section does not include adaptation strategies and is focused on actions recommended to identify regional considerations and partnerships, including assess regional context of vulnerability, evaluate impacts beyond site-specific design, optimize capital investment opportunities, and prioritize serves and assets that serve vulnerable populations.

***RC-1. Assess Regional Context of Vulnerability:*** There may be regional projects that would reduce the exposure and risk rating for the project and assets. The project may also serve to provide regional climate benefits. The preliminary Climate Risk Screening Output does not serve as a risk and vulnerability assessment. If the exposure and risk ratings are moderate or high, it is encouraged that the project owner evaluate existing regional plans and vulnerability assessments. The existing plans may also identify other regional projects that may provide benefits such as flood protection, upland stormwater storage, etc. If no existing studies are available, and the project owner should consider conducting a formal risk and vulnerability assessment.

- *Example Best Practice*: Mystic River Watershed Association – Regional Mystic Collaborative Webpage
- *Practice Relevance*: The Mystic River Watershed Association is spear heading the Regional Mystic Collaborative, which coordinates efforts across 18 cities and towns with the recognition that climate change and associated impacts cannot be solved by a single municipality or project and will take a full watershed approach. The webpage features a map that links to each town's Municipal Vulnerability Preparedness plan and municipal members.

***RC-2. Evaluate Impacts beyond site-specific design***: Due to the interconnected nature of natural and manmade systems, the project owner should evaluate the off-site effects of a proposed project on the region to avoid unintended consequences and maximize benefits. Additionally, the project owner should understand other proposed projects in the region and potential impacts/benefits to their project.

- *Example Case Study*: Draw 7 Park Flood Barrier, MA
- *Case Study Relevance*: Located at the mouth of the Mystic River watershed and adjacent to the Amelia Earhart Dam (AED), this site is a great demonstration of regional coordination in practice. The project scope includes park improvements, flood protection, and a living shoreline. Through climate vulnerability assessments prepared for the City of Cambridge, the site was identified as a critical flood pathway for the Cities of Cambridge and Somerville due to flanking of the AED. The height of the flood protection and alignment was coordinated with proposed AED improvements to leverage this opportunity to coordinate implementation and construction. This resulted in a higher design flood elevation than originally planned on the site to coordinate efforts with larger regional protection. Refer to Attachment 4.2B for additional case study details.

***RC-3. Optimize Capital Investment Opportunities***: Design and implementation efforts should leverage planned state or local investment. This provides an opportunity to coordinate plans and priorities during the design phase and identify projects that provide many resilience benefits. These opportunities may be identified in existing climate risk and vulnerability assessments (see RC-1).

- *Example Best Practice*: Main Street Roadway Raising, Charlestown Boston, MA – Webpage
- *Practice Relevance*: Through the Climate Ready Boston Charlestown Phase I project in 2017, a major near-term flood pathway was identified through the Schrafft's Center in Charlestown. Flood protection through 2030 for over 250 residents and 60 businesses could be achieved by elevating the roadway (Main Street) by an average of 2 ft. Roadway improvements were also planned as part of the ongoing Rutherford Avenue and Sullivan Square redesign project. Feasibility of raising the grades of Main Street is being evaluated as part of the on-going roadway improvements project.

***RC-4. Prioritize services and assets that serve vulnerable populations***: Standard practice concentrates efforts to provide value to the greatest number of users. Projects should evaluate the effects or benefits related to equity during design decisions. Prioritizing investments that serve vulnerable populations contributes to building broader social resilience.

- *Example Best Practice:* Evaluate additional impact to vulnerable populations (Research Paper)
- *Practice Relevance:* This journal article adds to the literature regarding the disproportionate exposure and risk vulnerable populations face during emergencies and contributes to resilience practice through the development of a tool, the Social Determinants of Vulnerability Framework. It identifies seven different social factors that drive vulnerability. It provides a quantitative analysis of social factors based on City of Boston data.

- *Example Best Practice:* Connected Communities Guidelines - PDF
- *Practice Relevance:* In coordination with New York City Housing Authority and NYC Planning department, the practical guide provides specific community engagement, open space design, and building preservation techniques for NYCHA campuses, yet generalizable to other contexts. The focus of the guide is that quality design can better connect residents to one another and to their surrounding community through different benefits. It identifies four main elements: community engagement, safety and security, health and resilience, and maintenance and operations. Through easy-to-understand and compelling graphics, the document goes further to provide checklists and tools.

### *4.1.3 FLEXIBLE ADAPTATION PATHWAYS GUIDELINES & BEST PRACTICES*

The draft Flexible Adaptation Pathways Guidelines are intended to encourage approaches to incorporate flexibility in project design and adaptation strategy selection. Designs should be able to function under current climate conditions as well as climate conditions through the recommended planning horizon, and beyond. Where possible the design approach should embrace strategies that adapt over time and respond to changing conditions. The case studies and best practices in this section reference different adaptation strategies, but the Guidelines do not provide recommendations for asset-specific adaptation strategies. Users will still need to perform standard practices to design assets, including evaluating site conditions, asset

sensitivities/thresholds and regulatory requirements. Project designs may include strategies that protect from climate hazards through the creation of barriers to shield a site from impact or accommodate climate hazards by mitigating consequences from impacts. Adaptation strategies will be tied to site specific conditions and analyses and decisions made by the Asset Owner, stakeholders, Technical Staff (planners, architects, and engineers).

***AP-1. Embed future capacity and design for uncertainty***: Assets should be designed for the recommended target planning horizon provided by the Climate Resilience Design Standards Tool, but users should consider what will happen beyond that planning horizon since climate change is still a concern beyond an asset's intended useful life. Examples of incorporating this in design include over designing a foundation that will allow flood height to be increased in the future; planning for a future pump in a lift station by designing the below ground infrastructure to accommodate the addition in the future, and/or planning land conservation for stormwater and heat mitigation strategies to be implemented in the future.

- *Example Best Practice*: City of Boston Public Works Department Climate Resilience Design Standards and Guidelines for Protection of Public Rights-of-way - PDF
- *Practice Relevance:* With the recognition of changing conditions throughout a project's intended useful life, and the abundance and importance of public rights-of-way, the City of Boston Public Works Department (BPWD) published guidelines that provide a design process for evaluating flood barriers to protect Boston's public rights-of-way. The BPWD design guidelines seek to achieve flood protection by 2070, with the option to add an additional 2 ft. of protection in the future. This was first implemented in the design of improvements at Langone Park & Puopolo Playground in Boston, MA by the Boston Parks and Recreation Department. The park is located along Boston Harbor in Boston's Historic North End. The resilience improvements on the site included raising grades and constructing a flood wall to the base flood elevation for 2070, and the wall is designed to be able to be increased in height the future if necessary.

***AP-2. Design for incremental change***: Designs should consider exposure and risk through an asset's useful life to identify flexible approaches to achieve the recommended Standards (return period, planning horizon, design criteria) identified through the Tool. Some projects may not be able to achieve the target design because of various infeasibilities (e.g. technical or financial limitations), and may need to use intermediate planning horizons to achieve the Standards over time.

- *Example Case Study*: Route 28 Roadway, Falmouth, MA
- *Case Study Relevance*: This project is for improvements to the Route 28 Roadway in Falmouth, MA. Coastal and riverine flood exposure and risk are high based on the preliminary Climate Risk Screening Output, but the risk increases through time based on review of the MC-FRM maps provided through the Standards. The project team is planning an incremental adaptation approach to meet the recommended Standards, including improvements beyond the project area from Falmouth Harbor to Morse Pond. The planned incremental improvements combine grey and green infrastructure measures. Waterfront assets, including Robbins Road and the Town Lift Station, are recommended to be elevated in the immediate near term where feasible. A berm and a living shoreline are planned along Falmouth Harbor for completion by 2050. The berm will be designed to be increased in 2070 as conditions change and include hard infrastructure improvements, such as outfall protection. The roadway improvements

are planned for 2070, and include designing a bridge/culvert, salt marsh, greenway, and open water connection between the Harbor and Morse Pond. The incremental approach allows the roadway to be planned and designed over time with additional nature-based benefits added to the design.

***AP-3. Encourage climate mitigation and other co-benefits***: Projects should consider carbon mitigation in design and ways to reduce their carbon footprint and support plans for a Carbon Neutral future. Additional co-benefits increase the benefit cost ratio for a project and provide more value beyond resilience.

- *Example Case Study*: Spaulding Rehabilitation Hospital, Boston, MA
- *Case Study Relevance*: Constructed in 2013, the Spaulding Rehabilitation Hospital located in the Charlestown Navy Yard is a LEED Gold Certified building. The project resulted in the cleanup of a brownfield site. The project considered carbon mitigation and smart use of energy. The building envelope was designed to conserve energy, and includes natural daylighting, window panels and shading systems. There is an energy efficient gas-fired combined heat power and building system. The resilience investment was $1.5 million rebated with utility costs with $500k of annual cost savings.

***AP-4. Prioritize nature-based solutions***: Natural systems and ecosystem services provide great economic value and social benefit, often untapped in non-resilient projects. Nature-based solutions may cost less than traditional gray approaches through reduced upfront investment, maintenance costs, or both, and as living systems, some can become self-sustaining over time. Nature-based solutions also provide many co-benefits for the environment and society.

- *Example Best Practice*: Natural Resilient Communities Resource Webpage
- *Practice Relevance:* Natural Resilience Communities provides a user-friendly, visually pleasing, interactive webpage that defines related terms, link to federal resources, and identifies a wide variety of detailed technical solutions and case studies. Users can choose from several different hazard flooding and erosion type, regional location, community type, scale, and cost.

- *Example Best Practice:* Town of Brookline Climate Resilience Design Guidance - PDF
- *Practice Relevance:* This Design Guidance document focuses on how Low Impact Development, at the municipal level, can be used to increase resilience of new and planned development. It provides recommendations and resilience Best Management Practices for cost, maintenance, and architectural design for temperature hot spots and FEMA flood zones. It is simple to read with clear graphics and linked resources.

***AP-5. Prepare for current and future operational and maintenance needs:*** Operations and maintenance needs, both under current and future climate conditions, should be identified early in the design phase and communicated to the Asset Owners and State Agency Project Managers. Technical Staff should explore how those demands may impact design and Asset Owners should prepare governance structures to support maintained resilience through the project's useful life.

- *Example Best Practice*: City of Boston Public Works Department (BPWD) Climate Resilience Design Standards and Guidelines for Protection of Public Rights-of-way - PDF – Operations and Maintenance Considerations

- *Practice Relevance*: Operations and maintenance (O&M) are critical components in preparing for and adapting to climate change. Though often overlooked in the design and planning phase, thoughtful consideration has clear implications to the long-term function of assets and sustainability of budgets. The BPWD Guidelines provide a framework for estimating annual operating costs and identifying O&M needs associated with design features.

## 4.2 CASE STUDIES OVERVIEW

Several case studies were identified to illustrate the Guidelines and best practices. The case studies provide examples for each applicable Guideline category. These case studies are real-world projects that are in various stages of planning, design, and construction. As such, the preliminary Climate Risk Screening Output from the Tool is provided, but the calculated values for the recommended Standards are not included. For real-world examples on calculating the recommended design criteria, please review Section 3. For case study examples for the Guidelines, see Attachment 4.2.A and Attachment 4.2.B.

## 4.3 FORMS OVERVIEW

The forms accompany the Guidelines and serve to document project information and considerations. The forms are comprehensive and include documentation of the inputs/outputs from the Standards Tool, the calculated design criteria values, site suitability considerations, regional coordination considerations, and flexible adaptation pathways considerations. The forms are structured as follows:

- Project Overview & Details – complete for overall project
- Asset Details – complete for each asset
- Climate Risk Screening Output – complete for overall project and each asset
- Site Suitability – complete for overall project
- Recommended Standards Output – complete for each asset
- Regional Coordination – complete for overall project
- Flexible Adaptation Pathways – complete for overall project

### *4.3.1 PROJECT OVERVIEW & DETAILS*

1. Preparer Name: Click or tap here to enter text.
2. Preparer Contact Information: Click or tap here to enter text.
3. Project Team and Roles: Click or tap here to enter text.
4. Project Agency/Client: Click or tap here to enter text.
5. Project Location/Municipality, identify address and tax lot number: Click or tap here to enter text.
6. Project location LAT/LONG: Click or tap here to enter text.
7. Project Name: Click or tap here to enter text.
8. Project Goals and Description: Click or tap here to enter text.
9. Project Beneficiaries (who will the project serve): Click or tap here to enter text.
10. Project Capital Cost: Click or tap here to enter text.

11. Identify major physical assets that are proposed as part of the project (facilities, structures, utilities, natural resources, etc.): Click or tap here to enter text.

### *4.3.2 ASSET DETAILS*

12. For ***each asset*** identified above, use the Climate Resilience Design Standards Tool to document the following information. *Note: the table will need to be completed for each asset*.

| Tool Input | **LIST ASSET HERE** |
|---|---|
| Asset Category | |
| Asset Type | |
| Asset Sub-Type | |
| Construction Type | |
| Useful Life | |

* Copy the table for each asset.

### *4.3.3 CLIMATE RISK SCREENING OUTPUT*

13. Based on the exposure rating output provided in the Tool, provide the following information on the ***project*** exposure:

| Climate Parameter | Project Exposure Rating | | | |
|---|---|---|---|---|
| Sea Level Rise/ Storm Surge | ☐Not Exposed | ☐Low Exposure | ☐Moderate Exposure | ☐High Exposure |
| Extreme Precipitation – Riverine | ☐Not Exposed | ☐Low Exposure | ☐Moderate Exposure | ☐High Exposure |
| Extreme Precipitation – Stormwater | ☐Low Exposure | | ☐Moderate Exposure | ☐High Exposure |
| Extreme Heat | ☐Low Exposure | | ☐Moderate Exposure | ☐High Exposure |

14. Based on the risk rating output provided in the Tool, provide the following information for ***each asset***. *Note: the table will need to be provided for each asset.*

| Climate Parameter | Asset Risk Rating - **LIST ASSET HERE** | | | |
|---|---|---|---|---|
| Sea Level Rise/ Storm Surge | ☐Not Exposed | ☐Low Risk | ☐Moderate Risk | ☐High Risk |
| Extreme Precipitation – Riverine | ☐Not Exposed | ☐Low Risk | ☐Moderate Risk | ☐High Risk |
| Extreme Precipitation – Stormwater | ☐Low Risk | | ☐Moderate Risk | ☐High Risk |
| Extreme Heat | ☐Low Risk | | ☐Moderate Risk | ☐High Risk |

* Copy the table for each asset.

### *4.3.4 SITE SUITABILITY (SS)*

Provide the responses to the following questions related to the ***overall project***.

#### *SS-1 Reduce exposure to climate hazards.*

SS-1.1 Does the site currently function as the asset type(s) identified for major physical assets in Project Inputs for the Tool? ☐ Yes ☐ No

SS-1.2 What makes this site desirable? Is the function, history, or community significance of the asset requiring that specific location and its assets? Click or tap here to enter text.

SS-1.3 Are there notable elevational changes on-site that may expose the assets to additional risk (such as increased water flow, erosion)? ☐ Yes ☐ No

If yes, identify and describe. Click or tap here to enter text.

SS-1.4 Are there other locations where this asset could be relocated away from coastal and/or riverine exposure, particularly high exposure areas (such as FEMA A or V Zones, etc.)? Click or tap here to enter text.

SS-1.5 Are there other on-site locations where critical assets can be relocated away from coastal and/riverine exposure and impact? ☐ Yes ☐ No

If not, what makes the relocation unfeasible or impractical at this time?
Click or tap here to enter text.

SS-1.6 Is access to the site threatened by current or future flood impacts? ☐ Yes ☐ No

If yes, describe. Click or tap here to enter text.

#### *SS-2 Mitigate adverse climate impacts and provide benefits.*

SS-2.1 Does the site have the opportunity to provide the following at the neighborhood scale?

SS-2.1.1 Coastal flood protection? ☐ Yes ☐ No

SS-2.1.2 Inland stormwater protection? ☐ Yes ☐ No

SS-2.1.3 Extreme heat mitigation? ☐ Yes ☐ No

SS-2.2 Do any of the abovementioned sit opportunities provide additional social or co-benefits?

☐ Yes ☐ No

If yes, identify and describe. Click or tap here to enter text.

SS-2.3 What benefits are provided directly to vulnerable populations?
Click or tap here to enter text.

SS-2.4 Will the project require removal of existing infrastructure or structures? ☐ Yes ☐No

If yes, describe. Click or tap here to enter text.

SS-2.5 How will adverse impacts (to the surrounding neighborhood) be mitigated (whether during demolition, remediation, construction, or operation)? Click or tap here to enter text.

SS-2.6 Could the site provide assets or resources for neighborhood scale or regional emergency operations (such as staging, logistics/distribution, sheltering, response)? ☐ Yes ☐ No

***SS-3 Protect, conserve, and restore critical natural resources on-site and off-site.***

SS-3.1 What type of natural ecosystems currently exist at the site (forest, grassland, freshwater, wetland, estuary, ocean/coastal)? Click or tap here to enter text.

SS-3.2 Is the site an urban, semi-urban, or rural location? Click or tap here to enter text.

SS-3.3 Is there evidence of endangered species at the site or that use the site? ☐ Yes ☐ No

SS-3.4 From currently accessible information and data, will environmental remediation be necessary/likely? ☐ Yes ☐ No

If yes, describe. Click or tap here to enter text.

SS-3.5 Is protection, conservation, or restoration of natural resources planned for implementation on site? How so? Click or tap here to enter text.

SS-3.6 Will the project be submitted for MEPA review? ☐ Yes ☐ No

### *4.3.5 RECOMMENDED CLIMATE RESILIENCE DESIGN STANDARDS*

*****COPY & COMPLETE THIS SECTION FOR EACH ASSET*****

15. List Asset Here: Click or tap here to enter text.
16. Based on the Standards output provided in the Tool, provide the Recommended Tiered Methodology:

☐ Tier 1 (low level of effort) ☐ Tier 2 ☐ Tier 3 (high level of effort)

17. Based on the Standards output provided in the Tool, complete the following table for:

***Sea Level Rise/Storm Surge***.

| Sea Level Rise/ Storm Surge Standard | Output from Tool |
|---|---|
| Recommended Data Source | |
| Recommended Return Period | |
| Recommended Target Planning Horizon | |
| Recommended Intermediate Planning Horizon (if applicable) | |

| Sea Level Rise/Storm Surge Design Criteria | Output from Tool | Calculated Design Criteria Value Based on Tiered Methodology[1] Intermediate Planning Horizon (if applicable) | Calculated Design Criteria Value Based on Tiered Methodology[1] |
|---|---|---|---|

| | | | Recommended Standards |
|---|---|---|---|
| Tidal Benchmarks | ☐ Yes ☐ No | | |
| Base Flood Elevation for Design Storm | ☐ Yes ☐ No | | |
| Design Flood Elevation for Design Storm | ☐ Yes ☐ No | | |
| Wave Heights for Design Storm | ☐ Yes ☐ No | | |
| Duration of Flooding | ☐ Yes ☐ No | | |
| Design Flood Velocity | ☐ Yes ☐ No | | |
| Wave Forces | ☐ Yes ☐ No | | |
| Scour or Erosion | ☐ Yes ☐ No | | |

1. Include units of measurement and/or datum.

18. Please identify if any of the recommended Sea Level Rise/Storm Surge Design Criteria are not applicable for your site and why. Click or tap here to enter text.

19. Based on the Standards output provided in the Tool, complete the following table for ***Extreme Precipitation***.

| Extreme Precipitation Standard | Output from Tool |
|---|---|
| Recommended Data Source | |
| Recommended Return Period | |
| Recommended Planning Horizon | |

| Extreme Precipitation Design Criteria | Output from Tool | Calculated Design Criteria Value Based on Tiered Methodology [1] and Recommended Standards |
|---|---|---|
| Total Precipitation Depth for 24-hour Design Storms | ☐ Yes ☐ No | |
| Peak Intensity for 24-hour Design Storms | ☐ Yes ☐ No | |
| Riverine Peak Discharge | ☐ Yes ☐ No | |
| Riverine Peak Flood Elevation | ☐ Yes ☐ No | |
| Duration of Flooding for Design Storm | ☐ Yes ☐ No | |
| Flood Pathways | ☐ Yes ☐ No | |

1. Include units of measurement and/or datum.

20. Please identify if any of the recommended Extreme Precipitation Design Criteria are not applicable for your site and why. Click or tap here to enter text.

21. Based on the Standards output provided in the Tool, complete the following table for ***Extreme Heat***.

| **Extreme Heat Standard** | **Output from Tool** |
|---|---|
| Recommended Data Source | |
| Recommended Confidence Interval | |
| Recommended Planning Horizon | |

| **Extreme Heat Design Criteria** | **Output from Tool** | **Calculated Design Criteria Value Based on Tiered Methodology[1] and Recommended Standards** |
|---|---|---|
| Annual/Summer/Winter Average Temperature | ☐ Yes ☐ No | |
| Summer Heat Index | ☐ Yes ☐ No | |
| Days Per Year with Maximum Temperature > 95°F | ☐ Yes ☐ No | |
| Days Per Year with Maximum Temperature > 90°F | ☐ Yes ☐ No | |
| Days Per Year with Minimum Temperature < 32°F | ☐ Yes ☐ No | |
| Number of Heat Waves Per Year | ☐ Yes ☐ No | |
| Average Heat Wave Duration (days) | ☐ Yes ☐ No | |
| Cooling Degree Days (base = 65°F) | ☐ Yes ☐ No | |
| Heating Degree Days (base = 65°F) | ☐ Yes ☐ No | |
| Growing Degree Days | ☐ Yes ☐ No | |

1. Include units of measurement.

22. Please identify if any of the recommended Extreme Heat Design Criteria are not applicable for your site and why. Click or tap here to enter text.

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### *4.3.6 REGIONAL COORDINATION (RC)*

Provide the responses to the following questions related to the ***overall project***.

**RC-1 *Assess regional context of vulnerability.***

RC-1.1 Does this site or area provide or contribute to regional climate resilience?
Click or tap here to enter text.

RC-1.2 Are there existing climate vulnerability or risk assessments available for the area?
☐ Yes ☐ No

RC-1.3 Are there any regulatory challenges/ loopholes complicating coordination? ☐ Yes ☐ No

If yes, identify those complications. Click or tap here to enter text.

**RC-2 *Evaluate impacts beyond site-specific design.***

RC-2.1 What are the off-site impacts of the project?

RC-2.1.1 Off-site unintended consequences (For example, harm to natural resources, public health & safety, downstream erosion/scour, etc.) Click or tap here to enter text.

RC-2.1.2 Off-site benefits (For example, provides emergency services for response/recovery, encourages economic development, improves public health & safety, improves natural resources, etc.) Click or tap here to enter text.

RC-2.2 Are there regional characteristics that affect or benefit the ability of a project to meet the recommended standards? (For example, location in watershed, urban heat island, floodplain, etc.) ☐ Yes ☐ No

If yes, identify and describe. Click or tap here to enter text.

RC-2.3 How will the project impact other regional projects?

RC-2.3.1 Are there on-going or planned regional projects that will affect or benefit the project site? ☐ Yes ☐ No

If yes, identify and describe. Click or tap here to enter text.

RC-2.3.2 Are there alternatives proposed in the project design if those regional projects are not advanced? ☐ Yes ☐ No

If yes, identify and describe. Click or tap here to enter text.

**RC-3 *Optimize capital investment opportunities.***

RC-3.1 Are there additional planned or on-going regional projects that could result in mitigation of climate impacts for this project? ☐ Yes ☐ No

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If yes, identify these planned or on-going projects and the benefit to the project.

Click or tap here to enter text.

RC-3.2 Are there opportunities that would provide more regional benefit for resilience investment than if site-specific improvements to meet the standards are made? (For example, flood barrier closer to the point of origination, upgradient stormwater management, etc.) ☐ Yes ☐ No

If yes, identify these opportunities and the benefit to the project.

Click or tap here to enter text.

RC-3.3 What funding is available for the project to meet the recommended climate standards?

Click or tap here to enter text.

**RC-4 *Prioritize services and assets that serve vulnerable populations.***

RC-4.1 Does project provide essential services to vulnerable populations? ☐ Yes ☐ No

If yes, describe. Click or tap here to enter text.

RC-4.2 How does the project promote social resilience and equity? Click or tap here to enter text.

RC-4.3 Could the site support emergency preparedness, response, or recovery efforts? ☐ Yes ☐ No

If yes, describe. Click or tap here to enter text.

### *4.3.7 FLEXIBLE ADAPTATION PATHWAYS (AP)*

Provide the responses to the following questions related to the ***overall project***.

**AP-1 *Embed future capacity and design for uncertainty.***

AP-1.1 Will the asset still be serving its primary or secondary function at the end of its intended useful life when re-investment is needed? Click or tap here to enter text.

AP-1.2 Does your design have the ability to adapt to future climate conditions beyond what is recommended for Climate Resilience Design Standards? Please indicate how the design can be adapted and to what extent. ☐ Yes ☐ No

AP-1.2.1 SLR/SS Click or tap here to enter text.

AP-1.2.2 Precipitation (Stormwater Flooding) Click or tap here to enter text.

AP-1.2.3 Precipitation (Riverine Flooding) Click or tap here to enter text.

AP-1.2.4 Heat Click or tap here to enter text.

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AP-1.3 Is there opportunity for below ground infrastructure (foundations, utilities, etc.) to be oversized for uncertainty? ☐ Yes ☐ No

If yes, describe. Click or tap here to enter text.

### AP-2 *Design for incremental change.*

AP-2.1 When is the asset anticipated to be exposed to climate events?

AP-2.1.1 SLR/SS Click or tap here to enter text.

AP-2.1.2 Other (if data are available) Click or tap here to enter text.

AP-2.2 If the climate risk changes through the asset's useful life, can the project be designed/ constructed incrementally to mitigate risk? ☐ Yes ☐ No

If yes, describe. Click or tap here to enter text.

AP-2.3 If the recommended Standards are infeasible, what plans are in place to achieve the Standards over time? Click or tap here to enter text.

### AP-3 *Encourage climate mitigation and other co-benefits.*

AP-3.1 How can any of the assets or site provide other current benefits, beyond its primary use?

AP-3.1.1 Carbon Mitigation/Greenhouse gas reduction Click or tap here to enter text.

AP-3.1.2 Equity & Social Resilience Click or tap here to enter text.

AP-3.1.3 Economic Development Click or tap here to enter text.

AP-3.1.4 Public Health Benefits Click or tap here to enter text.

AP-3.1.5 Natural Resources/Ecosystem Services Click or tap here to enter text.

AP-3.1.6 Sustainability Click or tap here to enter text.

AP-3.2 Do these benefits change over time due to climate impacts? ☐ Yes ☐ No

If yes, identify and describe. Click or tap here to enter text.

### AP-4 *Prioritize nature-based solutions.*

AP-4.1 Are nature-based solutions being implemented on the site?

AP-4.1.1 Are nature-based solutions part of a coastal management strategy? ☐ Yes ☐ No

AP-4.1.2 Are nature-based solutions part of a stormwater management strategy? ☐ Yes ☐ No

AP-4.1.3 Are nature-based solutions part of a heat management strategy? ☐ Yes ☐ No

AP-4.2 How are these nature-based solutions changing over time due to climate impacts? Click or tap here to enter text.

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AP-4.3 How do nature-based solutions integrate with proposed or existing hard/gray infrastructure? Click or tap here to enter text.

**AP-5 *Prepare for current and future climate resiliency operational and maintenance needs*.**

AP-5.1 What are the current maintenance and operational needs for the site (nature-based solutions, adaptation strategies, sustainability, etc.)? Will the extent of these needs change over time due to climate impacts? Click or tap here to enter text.

AP-5.2 Who are responsible for maintenance and operational services for the site? Does the responsible party change over time? Click or tap here to enter text.

AP-5.3 What are the current maintenance and operational costs? Do these costs increase over time due to climate impacts? Click or tap here to enter text.

AP-5.4 When are your typical repair cycles? Will frequency of maintenance change over time due to climate impacts? Click or tap here to enter text.

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# Section 4 Attachments

Attachment 4.2A – Draft MassDOT District Maintenance Facility Relocation Case Study

Attachment 4.2B - Draft DCR Draw 7 Park, Flood Barrier, and Living Shoreline Case Study

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## Attachment 4.2A – Draft MassDOT District Maintenance Facility Relocation Case Study

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RMAT **CASE STUDY**

# MassDOT's Fuel Depot Complex

Milton, MA

## PROJECT INPUTS

**Convertion of the current Fuel Depot complex to Primary District 6 Maintenance Facility. The new facility would be the staging and deployment station during emergency conditions (e.g., blizzards, etc.). At this site, the project would be classified as a major repair or retrofit.**

**Asset Category**: Building/Facility
**Asset Type**: Typically Occupied
**Asset Subtype**: Other

| CRITICALITY |
|---|
| High |

| EXPOSURE RATING | CLIMATE PARAMETER | RISK RATING |
|---|---|---|
| High Exposure | Coastal/SLR | High Risk |
| Moderate Exposure | Precipitation Flooding | Moderate Risk |
| Moderate Exposure | Riverine Flooding | Moderate Risk |
| Moderate Exposure | Extreme Heat | Moderate Risk |

**Ecosystem Services**: N/A

**Intended useful life**: 50 years

| TARGET PLANNING HORIZON | | |
|---|---|---|
| 2030 | 2050 | **2070** |

## CLIMATE RESILIENCE DESIGN GUIDELINES

### SITE SUITABILITY GUIDELINES (SS)

Guidelines related to geographic location, existing conditions, and asset placement. Assess and re-assess early in the design phase to ensure that the site can serve its intended function, before, during and after climate impacts. These guidelines do not include adaptation strategies.

| | Guideline | Context and Design Opportunity |
|---|---|---|
| SS-1 | Reduce exposure to climate hazards. | The site is currently a Fuel Depot Complex that was proposed to be converted to be the Primary District 6 Maintenance Facility for MassDOT.<br><br>**Opportunity:** Based on the present and future coastal risk, MassDOT decided to not relocate the Primary District 6 Maintenance Facility here. The new facility was intended to be the staging and deployment station during emergency conditions. |
| SS-2 | Mitigate adverse climate impacts and provide benefits. | Not applicable. |
| SS-3 | Protect, conserve, and restore critical natural resources on-site and off-site. | Not applicable. |

Given the functional requirements of the site, flood exposure, and high criticality of the asset, relocation away from the climate hazards was recommended. No additional regional considerations or flexible adaptation pathways are considered for this site.

Figure 1. (top, left) Aerial view of site.

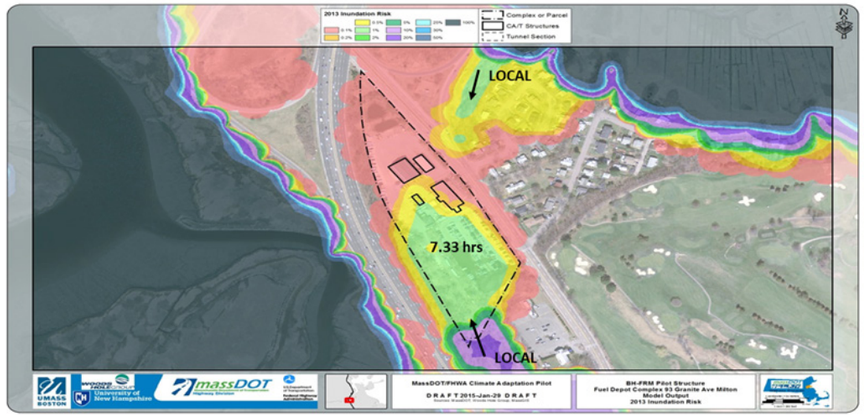


Figure 2. BH-FRM Present Day Coastal Flood Annual Exceedance Probabilities, Flood Entries, and Residence Times.

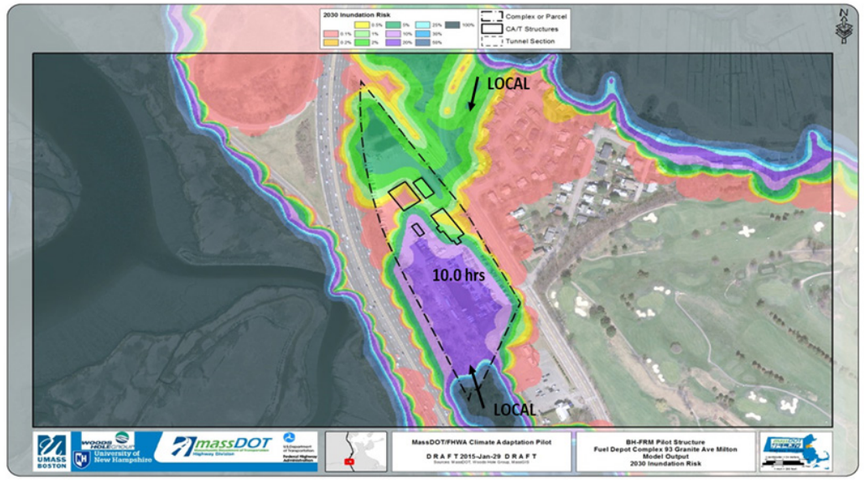


Figure 3. BH-FRM 2030 Coastal Flood Annual Exceedance Probabilities, Flood Entries, and Residence Times.

## Attachment 4.2B – Draft DCR Draw 7 Park, Flood Barrier, and Living Shoreline Case Study

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RMAT **CASE STUDY**

# Draw Seven Park

Somerville, MA

## PROJECT INPUTS

**Park improvements include flood control, stormwater management improvements, and a living shoreline. Flood control features are new construction.**

Flood Control
**Asset Category**: Infrastructure
**Asset Type**: Dam safety and flood control
**Asset Subtype**: Other

**Intended useful life**: 41 - 50 yrs

Living Shoreline
**Asset Category**: Natural Resource
**Asset Type**: Wetland resource area - coastal
**Asset Subtype**: Coastal wetland

**Intended useful life**: 11 - 20 yrs

| ASSET | CRITICALITY |
|---|---|
| Infrastructure | High |
| Natural Resource | Medium |

**Ecosystem Services**: Improves water quality, decarbonization/ carbon sequestration, flood/ storm protection, oxygen production, park

| EXPOSURE RATING | CLIMATE PARAMETER | RISK: Infrastructure | RISK: Natural Resource |
|---|---|---|---|
| High Exposure | Coastal/SLR | High Risk | High Risk |
| Moderate Exposure | Urban Flooding | High Risk | Moderate Risk |
| High Exposure | Riverine Flooding | High Risk | High Risk |
| Moderate Exposure | Extreme Heat | High Risk | Moderate Risk |

| TARGET PLANNING HORIZON: FLOOD CONTROL | | |
|---|---|---|
| 2030 | 2050 | **2070** |
| **TARGET PLANNING HORIZON: LIVING SHORELINE** | | |
| 2030 | **2050** | 2070 |

## CLIMATE RESILIENCE DESIGN GUIDELINES

### SITE SUITABILITY GUIDELINES (SS)

Guidelines related to geographic location, existing conditions, and asset placement. Assess and re-assess early in the design phase to ensure that the site can serve its intended function, before, during and after climate impacts. These guidelines do not include adaptation strategies.

| | Guideline | Context and Design Opportunity |
|---|---|---|
| SS-1 | Reduce exposure to climate hazards. | The site is currently not vulnerable to flooding (with the exception of the living shoreline), but will be in the near-term, based on 2030 MC-FRM model results.<br>**Opportunity:** Relocation of the park was not considered since it is intended to serve as a public park, and it is an urban area where opportunities for open space (both passive and active) are limited. |
| SS-2 | Mitigate adverse climate impacts and provide benefits. | Located at the mouth of the Lower Mystic River watershed, the exposure ratings for both coastal and riverine flooding are high.<br>**Opportunity:** Based on the preliminary sea level rise and storm surge exposure and risk rating score, the park revitalization could be expanded to include flood protection and a living shoreline, on-site water storage could mitigate stormwater flooding, and increased tree canopies could mitigate heat effects. |
| SS-3 | Protect, conserve, and restore critical natural resources on-site and off-site. | The project location at this watershed is where the freshwater meets the seawater.<br>**Opportunity**: There are different types of ecosystems to conserve, including freshwater and seawater resources. There are few trees on the site, providing opportunities to increase the tree canopy as part of the park improvements. |

Figure 1. (top, left) Aerial view of site.

### REGIONAL COORDINATION GUIDELINES (RC)

Guidelines identifying how resilient design and implementation can be coordinated across Secretariats, State Agencies, and jurisdictions. The goal is to provide the most benefit to the Commonwealth and identify opportunities for collaboration and promotion of resilience.

| | Guideline | Context and Design Opportunity |
|---|---|---|
| RC-1 | Assess regional context of vulnerability. | In the City of Cambridge Vulnerability Assessment, and through additional flood modeling prepared for regional efforts, the site was identified as a critical flood pathway for future flooding due to flanking of the Amelia Earhart Dam (AED). Flooding would affect the Cities of Cambridge and Somerville and the MBTA Orange Line.<br>**Opportunity:** The site is capable of providing regional flood protection by addressing the critical flood pathway through the site and by coordination with the AED. |
| RC-2 | Evaluate impacts beyond site-specific design. | Given site location and future flood exposure, the team should coordinate with multiple municipalities and impacted entities.<br>**Opportunity:** This project will be coordinated with efforts to improve the resilience of the AED, which can also provide flood protection to the Cities of Cambridge and Somerville. |
| RC-3 | Optimize capital investment opportunities. | Park improvements were planned as part of the DCR Capital Improvements Plan. The flood protection and living shoreline can be included in existing planned investment to provide additional benefits.<br>**Opportunity:** Flood protection height and alignment will be coordinated with proposed AED improvements to optimize implementation and construction. |
| RC-4 | Prioritize services and assets that serve vulnerable populations. | A barrier could provide flood protection for the cities of Cambridge and Somerville, and the MBTA Orange line, which has the 2nd highest daily ridership in the system and many commuter rail connections. |

RMAT **CASE STUDY**

**Draw Seven Park**
Somerville, MA

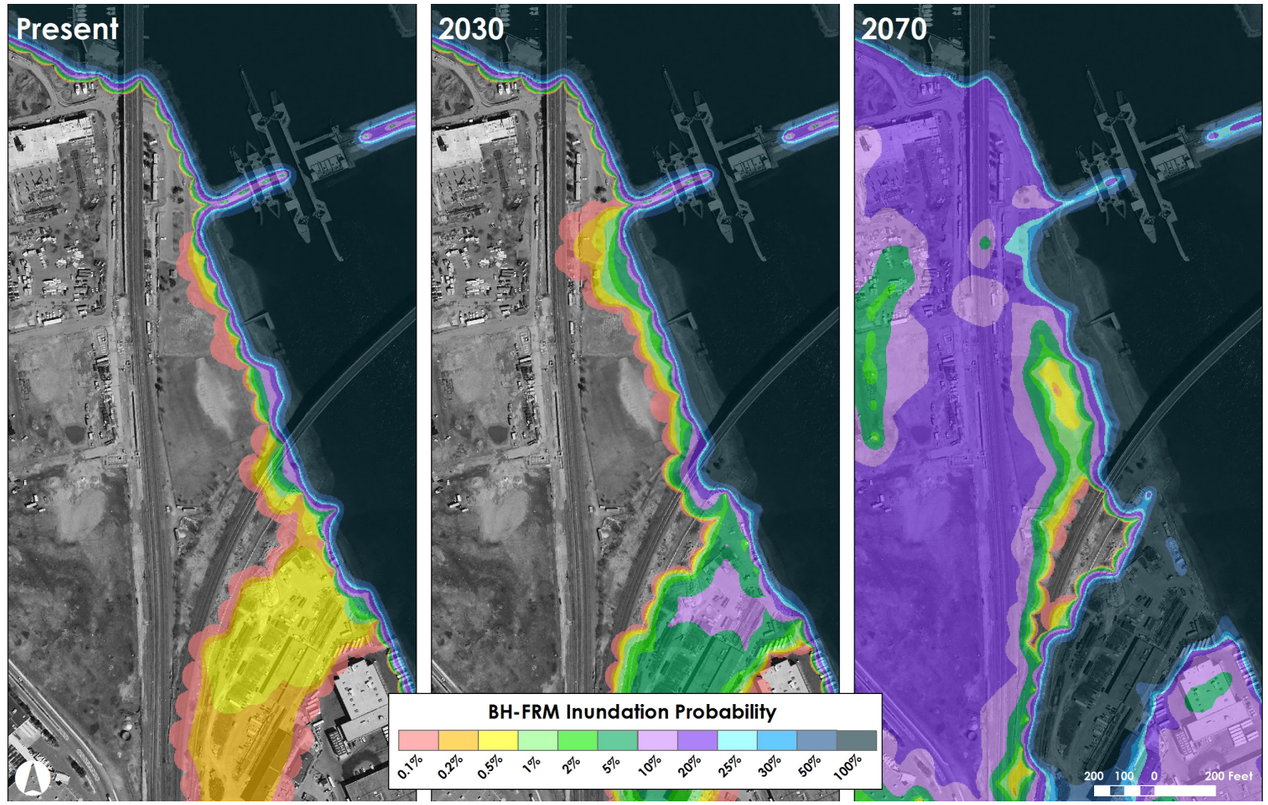
## CLIMATE RESILIENCE DESIGN GUIDELINES

### FLEXIBLE ADAPTATION PATHWAYS GUIDELINES (AP)

Guidelines recommending approaches to incorporate flexible climate standards into project design. Designs should be able to function under current climate conditions as well as future planning horizons. Where possible, the approach should embrace strategies that adapt over time and respond to changing conditions.

Figure 2. (top) Draft rendering of multi-layered design to incorporate co-benefits and flexible flood protection systems.

Figure 3. (bottom) BH-FRM Coastal Flood Probability Maps. Expanding flood risk over time, where the floodplain expands from the park towards Somerville and Cambridge.




| | Guideline | Proposed Design Strategy |
|---|---|---|
| AP-1 | Embed future capacity and design for uncertainty. | The open space is designed so that the living shoreline can migrate into the site as sea level rises. The park will likely undergo reinvestment in 2050 (parks have a useful life of roughly 30 years) where investment in the barrier and other site features can be re-evaluated.<br><br>**2070+ Strategy:** The grading along the waterfront is designed to allow the living shoreline to migrate into the park as sea level rises. The flood height of the barrier was increased to the 500-year return period for 2070 (the Standards recommended a 200-year return period for 2070) to be consistent with design improvements planned for AED as part of regional analyses. |
| AP-2 | Design for incremental change. | The project will meet 2070 climate conditions as recommended in the Climate Resilience Design Standards, but the park will function differently during its useful life.<br><br>**2030 Strategy:** The site is able to function as a flood barrier for future flood conditions through grading. For expected 2030 coastal flooding, site grading will allow most of the site to stay dry. On-site bioretention will mitigate stormwater flooding and increased tree canopies will mitigate heat effects. The project proposes a freshwater wetland on the freshwater side of the AED and a living shoreline on the coastal side.<br><br>**2070 Strategy:** For expected 2070 coastal flooding, site grading will allow critical access to the AED and some park pathways to remain dry and block the flood pathway through the site. |
| AP-3 | Encourage climate mitigation and other co-benefits. | In addition to the wetlands and living shoreline, proposed park improvements include increased tree canopy, increased public access to the waterfront with a future connection to the Encore Resort in Everett and potential MBTA access through the park, and a reduction in parking on-site. **Co-Benefits:** Equity & Social Resilience, Public Health, Natural Resources, Ecosystem Services. |
| AP-4 | Prioritize nature-based solutions. | The project features a living shoreline, freshwater wetland, bioretention basin, new passive open space park, and increased tree canopy. |
| AP-5 | Prepare for current and future operational and maintenance needs. | Operations at the AED are critical for regional flood protection. Site design prioritizes access to the AED, including during the 2070 design storm event. |